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ABSTRACT

A study was commissioned by a large petrochemical concern in order to validate professional degrees as a job entry requirement. The investigations considered two issues: (1) "Are activities performed by professionals (chemists and engineers) measurably different from the activities of subordinate technical personnel?" and "What aspects of professional education lead to professional competence?" Divided into two parts, the study initially employed the position analysis questionnaire (a standardized worker-oriented job element analysis instrument) in contrasted group comparisons of 420 professionals and 215 non-professionals. In the second study, restricted to 420 professionals, the critical incidents technique for analyzing job duties was utilized. In a cross validation technique, performance incidents elicited from individual chemists were independently reanalyzed by other chemists. Results of the various analytic techniques indicated that the curricula of professional education programs in chemistry and engineering can be related in a measurable way to professional competencies.
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TRACING PROFESSIONAL PROFICIENCIES BACK TO CURRICULA IN PROFESSIONAL EDUCATION: A CONTENT VALIDATION BASED ON THE CONVERGENT VALIDITY OF MULTIPLE JOB ANALYSIS MEASURES

ABSTRACT

The professional duties of exempt level personnel in a large industrial concern were analyzed with a variety of job analysis techniques, yielding information at several levels of comparability and specificity. Adequate performance of critical professional job elements and job activities was then traced back to the knowledge or skill gained through core curricula in relevant degree programs of professional education. The study was commissioned in order to validate professional degrees as a job entry requirement. A content validity design based on the convergence of multiple independent indicants was utilized.

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The entire enterprise of professional education is based on the assumption that education prepares students to become competent professionals. But suppose this assumption is challenged. Can it be empirically shown that professional competence is dependent on the content of professional education? This paper presents the results of a field study designed to find out.

Addressing related issues in the evaluation of educational outcomes, Ohmer Milton and John W. Edgerly (1977) sounded a timely warning:

If assessment is not improved from inside the profession, then it most surely will be put under pressure from the outside. Traditionally faculty members have enjoyed almost complete autonomy in their teaching performance. Until recently the courts had tended to avoid the academic bastions. But now they are beginning to intervene, and some observers believe such interventions will soon accelerate. This has resulted from several trends: an increased sophistication of students, a new regard for higher education as a social necessity and an individual right, the expansion of civil rights protections by public authority, and -- perhaps most important -- the new age of majority. (p. 50)

These concerns are based, in part, on the history of employment testing in industry. Because job tests have been challenged as discriminatory, several federal agencies now monitor employment testing. Only tests that meet stiff federal guidelines can be used to select minority job applicants.

But educational requirements are also vulnerable. In one of the landmark Supreme Court cases dealing with employment discrimination, the Court ruled that a high school diploma was an unfair job requirement (Griggs vs. Duke, 1970). This educational requirement was discriminatory and was not empirically related to job duties. Using this case as a precedent, educational requirements are now defined as "tests" that must meet the Federal Executive Agency Guidelines on Employment Selection Procedures (Federal Register, November 23, 1976).

PROBLEM

This field study grew out of a Federal agency challenge that an industrial firm demonstrate the job relatedness of its educational requirements, particularly for the positions of chemist and chemical engineer. In meeting this challenge, it was necessary to empirically demonstrate the relationship between professional activities of these personnel and professional education requirements.

Three varieties of validity evidence are sanctioned in the Federal guidelines: predictive validity, content validity, and construct validity. Content validity is most appropriate for professional degree requirements that may be challenged:

A demonstration of the relationship between the content of the selection procedure and the performance domain of the job is critical to content validity. Content validity may be shown if the knowledges, skills or abilities demonstrated in and measured by the selection procedure are substantially the same as the knowledges, skills or abilities shown to be necessary for job performance. The closer the content of the selection procedure is to actual work samples, behaviors or activities, the stronger is the basis for showing content validity. (41 CFR 60:3)

Within the context just described, empirical relationships between professional activities and professional education were investigated. The investigations were operationalized in terms of two issues:

ISSUE 1: ARE ACTIVITIES PERFORMED BY PROFESSIONALS MEASURABLY
DIFFERENT FROM THE ACTIVITIES OF SUBORDINATE
TECHNICAL PERSONNEL?

ISSUE 2: WHAT ASPECTS OF PROFESSIONAL EDUCATION LEAD TO
PROFESSIONAL COMPETENCE?

STUDY #1: PROFESSIONALS VS. TECHNICIANS

SUBJECTS:

The data source for this study consisted of selected personnel employed at a midwestern plant site of a large petrochemical concern. Technical and professional incumbents in positions requiring at least a bachelor's degree in chemistry or chemical engineering were the primary respondents. Additionally, a large number of non-professional incumbents working in the same work setting were included because the research design included contrasted group comparisons. Accordingly, the job incumbents who participated in the study were broken down as follows:

Professional Personnel	<u>420</u>
Non-Professional Personnel	<u>215</u>
total	<u>635</u>

INSTRUMENTATION:

The Position Analysis Questionnaire: A Standardized, Worker-Oriented Job Element Analysis Instrument. The PAQ was developed at the Occupations Research Center, Department of Psychological Sciences, Purdue University (McCormick, Jeanneret, & Mecham, 1972). The instrument describes jobs in terms of loadings on 32 job elements that have been derived through factor analysis. Scoring of the PAQ predicts the GATB aptitude profiles required of job incumbents (Intelligence, Verbal Aptitude, Numerical Aptitude, Spatial Aptitude, Form Perception, Clerical Perception, Motor Coordination, Finger Dexterity, and Manual Dexterity). Finally, the PAQ analysis highlights salient job elements that are of particular importance for the job under analysis.

At one stage in PAQ development and standardization, 3,700 jobs were included as a broad sample from which to develop factor analytic dimensions that would have

wide generalizability. As a result of this extended developmental and standardization process, the 194 item PAQ was particularly appropriate for the present study because jobs from several areas (e.g. chemistry, engineering, production, marketing, administration) could all be examined on the same dimensions. This horizontal comparison is complemented by vertical comparisons of a spectrum of job levels, from foreman and lower level administration and staff functions up to the level of high administrative managers. Since jobs could be empirically compared in terms of characteristic similarities and differences, this served as a solid foundation for a discriminant analysis of the components of programs in professional education.

In the present study, the median interjudge reliability for each of the 32 PAQ job elements was $r = .70$ ($p < .01$).

RESULTS:

(a) Bivariate Comparisons

Comparison of specific PAQ worker characteristics for positions that require a bachelor's degree or above with positions that do not require a degree reveal many pronounced differences between these groups. An outstanding example of these differences is indicated by the level of mathematical reasoning required for adequate functioning in the contrasted groups. For 129 employees matched for work setting but mismatched for degree level, the level of mathematical sophistication required for adequate job performance clearly distinguished professional and non-professional groups, $t(128) = 28.69$, $p < .0000000001$. On the basis of this and other bivariate comparisons, it is clear that positions which require degrees warrant different selection standards than jobs which do not

require a bachelor's degree. It is also clear that characteristics such as level of mathematical functioning are logically related to the curricula of professional education, since both chemists and engineers were required to take advanced mathematical studies beyond calculus.

(b) Job Family Clusters Based on PAQ Profile Comparisons

Computerized PAQ analyses provide for clustering jobs that have been analyzed into job families based on profile comparisons of worker characteristics. As indicated in the PAQ technical manual:

The most useful procedure is that of grouping jobs together into basic job families or clusters in terms of their similarities based on PAQ data. These job families make it possible to identify the patterns of work functions that comprise each such job family. In many instances these basic job families actually cut across departmental or divisional lines within an organization, and often the basic job families are obscured by a morass of job titles. (p. 16f.)

The results of this clustering (determined by comparing the standard errors of composite groups with the standard errors of component groups) indicated five family clusters. Of greatest interest here is the indication that technician level jobs in engineering and chemistry tended to differentiate themselves in terms of their professional performance domains.

The results reported thus far show rather clearly that non-degree jobs differ rather markedly from positions requiring professional education. Thus, the problem which arose in the Griggs vs. Duke Supreme Court case, in which jobs requiring degrees did not have significantly different worker requirement than lower level jobs, is here averted. However, these results alone do not indicate the precise nature of the correspondence between professional education and professional performance. To establish that further question, we need to examine the results of the methods used to gain this more finely focused analysis.

STUDY #2: RELATING PROFESSIONAL ACTIVITIES TO EDUCATIONAL CONTENT

SUBJECTS:

The second portion of the study was restricted to professional personnel. A total of 420 respondents participated by reporting particular job competencies that were dependent on the knowledge or skills gained in programs of professional education.

CRITICAL INCIDENT TECHNIQUE:

The critical incident job analysis technique, pioneered by John C. Flanagan of the American Institutes for Research, has proven to be a powerful method for gaining precise, behaviorally oriented descriptions of critical job duties. Flanagan defined "critical incident" as follows:

By an incident is meant any observable human activity that is sufficiently complete in itself to permit inferences and predictions to be made about the person performing the act. To be critical, an incident must occur in a situation where the purpose or intent of the act seems fairly clear to the observer and where its consequences are sufficiently definite to leave little doubt concerning its effects. (1954, p. 327)

The critical incident technique has been utilized in a wide variety of applications, including analysis of the performance of medical interns and residents by the National Board of Medical Examiners (1960, 1976).

In the present application, the critical incident technique was adapted for use in relating specific job duties to the educational backgrounds of incumbent employees. Participants were asked to report critical incidents in their performance area and then link these back to their educational preparation. The rationale for this approach is straightforward. The logical process of incumbents relating specific job activities to the knowledge or skills gained in professional education seems to capture the essence of "job relatedness".

CRITICAL INCIDENT RESULTS:

A large number of critical incidents could be traced to the professional education of chemists and engineers. A small sample of the job activities and educational correlates is presented for engineers:

Critical Job Duty	Related to Content Area in Education
"Calculate theoretical energy and raw materials consumptions for standards of performance"	"Courses in heat-material balances, standard stoichiometry"
"Prepare piping and instrument diagram"	"Courses in process design"
"Redesign existing plant to produce different products"	"Courses in fluid mechanics, physical metallurgy, higher math, thermodynamics, mass transfer and heat transfer"

CROSS VALIDATION TECHNIQUE:

The performance incident content analysis provided examples of critical job duties across a wide range of jobs. Among research chemists, enough performance incidents were collected from a large sample of chemists to permit further analysis.

The cross validation technique utilized is an adaptation of an aspect of the behavioral expectation scaling methodology developed by Smith and Kendall (1963). One of the steps in their scaling process is called "retranslation". Literally, this involves verification of the correctness of a linguistic translation by having a translated statement independently translated back into the original. The retranslation is then compared to the original for accuracy. In scale construction, an analogous procedure is followed by having raters independently sort activity descriptions back into the categories they were written to illustrate.

In the present study, performance incidents elicited from individual chemists were independently reanalyzed by other chemists. The retranslators attempted to assign job activities back into the educational content areas

illustrated by the author of the item. A large group of chemists was asked to attribute particular job competencies to one of the curricular content areas for a standard professional degree program in chemistry.

CROSS VALIDATION RESULTS

Analysis of the results of the retranslation process indicated levels of agreement for each competence/curriculum combination. Overall, it was clear that practicing chemists consistently attributed certain critical job competencies to content areas in their standard professional degree curriculum. Some examples indicate the kind of results acquired:

Critical Job Duty	Core Content Area	Agreement Level
<i>Correlate properties of foams with chemical structures</i>	<i>Organic Chemistry</i>	93%
<i>Interpret Spectral Data</i>	<i>Analytical Chemistry</i>	88%
<i>Study kinetics of a chemical reaction</i>	<i>Physical Chemistry</i>	89%
<i>Use the classical methods of chemical analysis</i>	<i>Inorganic Chemistry</i>	82%

A pooled inter-rater reliability calculated on the responses of chemists with identical job descriptions was $r = .67$ ($p < .01$) for the 33 item form used in this phase of the study.

In summary, these results show that the curricula of professional education programs in chemistry and engineering can be related in a measureable way to professional competencies. Although the results of this study strictly pertain only to the firm under investigation, the pattern of relationships may be extended to other programs in professional education.

DISCUSSION

It has been demonstrated by Campbell and Fiske (1959) and Campbell and Stanley (1966), among others, that fallible single measurements can be replicated in such a way that useful applied research is methodologically defensible. A similar set of assumptions underlies the endeavor reported here. None of the measures in this study, taken singly, rigorously demonstrate the postulated relations. But taken together, they function as independent replications which point in the same direction (convergent validity). As such, they serve as the research tools which make possible the examination of an important research issue in professional education.

EDUCATIONAL AND SCIENTIFIC IMPORTANCE OF THE STUDY

The research design, measurement technology, and results of this study merit the attention of other researchers in the area of professional education for several reasons:

- (1) The job analysis of professional activities is of potential utility in the evaluation and development of programs in professional education.

In some areas of professional education, particularly the health professions, changes in degree programs are made without systematic analysis of the criterion performance which is the target of professional education. Educational programs seem to be instituted in reaction to some reported inadequacy of previous programs. But such reports are hardly reliable indicators of the adequacy of the program under attack. A job analysis of professional performance activities that could be traced back to curricular content areas might serve as a powerful guide to modification of program content and emphases.

- (2) Job analysis technology is not widely known.

The Position Analysis Questionnaire developed at Purdue University, the critical incident technique developed by Flanagan, and the retranslation technique developed by Smith and Kendall are not widely utilized in educational

research. The present application of these techniques provides some indication of their utility.

(3) Gathering evidence in field research is basically a process of challenging plausible rival hypotheses.

Applied field research is rarely as rigorous as controlled laboratory experimentation. But this does not mean that applied field research cannot make a valuable contribution. Applied field research is most likely to be profitable when the research hypothesis is compared against plausible rival hypotheses (Campbell, 1969). If the rival hypotheses can be ruled out, then the research hypothesis is considered to be the most likely explanation of the data. In the present study, the research hypothesis was that professional education did lead to professional competence in essential job duties. Two rival hypotheses were disconfirmed: (1) positions with degree requirements do not differ from positions without degree requirements, and (2) positions with degree requirements do not utilize the skills acquired in programs of professional education. The disconfirmation of these rival hypotheses makes the basic research hypothesis most plausible.

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